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F.W.P.

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THE PREVENTION OF PEACH LEAF-CURL.

By W. A. MURRILL.

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CORNELL UNIVERSITY, ITHACA, N. Y., Feb. 20, 1900.

THE HONORABLE COMMISSIONER OF AGRICULTURE,
ALBANY, N. Y.

Sir:—This bulletin is submitted for publication under Chapter 430, of the Laws of 1899. It has been prepared by Mr. W. A. Murrill and embodies the results of experiments extending over one year together with a résumé of the investigations on the same subject which are set forth in full in Bulletin 164. The Peach Leaf Curl during the last few years has become a menace to the peach industry in many parts of the State. The two years' experiments lead to the conclusion that the leaf curl of the peach can be easily controlled when proper and timely treatment is given. This bulletin is valuable because it has established the fact that the foliage of peach trees, even of the more tender variety, may be kept healthy and vigorous, and because it gives specific directions as to the time of spraying, the kind of spray material and the method of application.

The investigations in Niagara County have been conducted on a large scale that some facts might be secured to guide the peach grower as to the cost and practicability of treating large orchards. The investigations conducted at Trumansburg were on a smaller scale but large enough to give reliable results.

I. P. ROBERTS,
Director.

THE PREVENTION OF PEACH LEAF-CURL.

In bulletin 164 of this Station, Dr. B. M. Duggar has given an account of the appearance and life history of the fungus causing leaf-curl of the peach, with the results of some very successful experiments undertaken by him for its prevention. It was for the purpose of farther testing these and other treatments on a commercial scale that the experiments here recorded were planned.

The Orchards Selected for Experiment.

The orchards selected for the experiments have, taken together, presented a variety of conditions of soil, moisture, and exposure, as well as wide differences in the trees themselves. The Elberta variety has been given the preference because of its well known susceptibility to curl, but Early Crawford, Hill's Chili, Brigdon, Mountain Rose, Globe, Beer's Late, and seedling trees have also been included in the experiments. Of these varieties, some trees have been young and others old, some fruiting heavily and others entirely without fruit, some isolated and some surrounded by trees of the same or different varieties, some sprayed during the season of '98, but most of them treated in '99 for the first time.

The Season of 1899.

The season of 1899 was a peculiar one and not very satisfactory for experiments with leaf-curl. The weather in April and early May was unusually bright and dry. The leaves were out much in advance of the flowers and were very large when the petals fell. The curl that appeared was doubtless developed for the most part by the short season of cold, rainy weather that occurred about the middle of May. There was little difference in varieties as regards the abundance of curl, but individual trees showed marked differences. The worst cases of curl I noticed were on Yellow St. John in the Bradley orchard near Somerset,

Niagara Co. Trees affected with the yellows or otherwise enfeebled showed little or no tendency to curl.

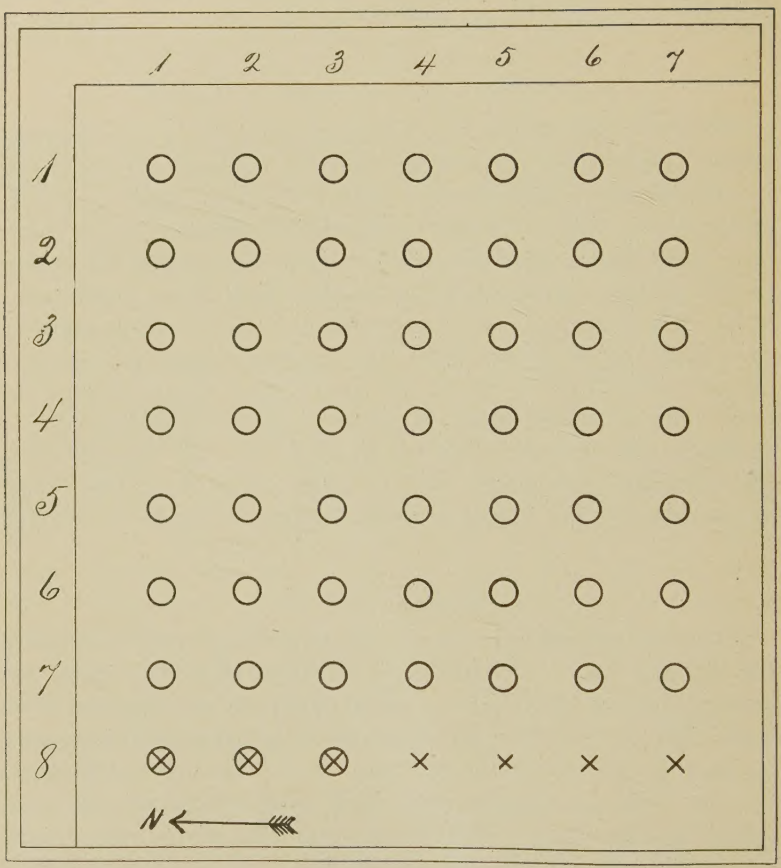
ESTIMATING THE AMOUNT OF CURL.

While the past season has not been favorable to the development of peach-curl, it has been possible to make the estimates in the following experiments with more than usual accuracy. In Mr. Lutts' Elberta block of one hundred and seventy-six trees, the curled leaves were all counted. The same method was used in Mr. Wright's orchard of one hundred and thirty-eight trees. With this experience as a basis and by tedious comparisons of row with row and tree with tree, stopping again and again to correct the estimates by actual counting, I have obtained the results given in the tables to follow. As a farther precaution against error, all records of treatments were left behind when the estimates were made ; and, in nearly every case, the owner of the orchard has kindly accompanied me to check the results.

EXPERIMENT I.

This is a continuation of the experiment described in Bulletin 164, pp. 379–380. The frontispiece, taken from Fig. 68 of that bulletin, shows the effect of early spraying as compared with late. The row on the right received its spraying with Bordeaux on April 8, the one on the left May 10. From the experience of the past year, we can add very little to the results already published for this block. Following is the plan of the experiment with a table showing the treatments used and their comparative effects on the curl. Early in the season, aphis and bud moth appeared in abundance, and a hail storm later on still farther complicated the injuries, so that the effects of the solutions on the foliage were not estimated.

PLAN OF EXPERIMENT I.

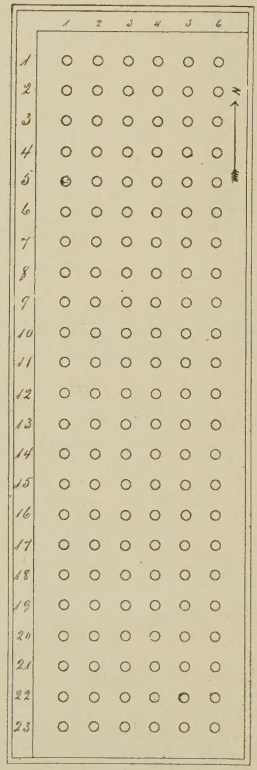


These eight rows, of seven trees each, were selected by Mr. Duggar, for his experiments in 1898. Copper carbonate alone is represented by x, but when preceded by Bordeaux mixture the x is inscribed in a circle.

EXPERIMENT I.—TABLE OF RESULTS.

Row.	Trees.	Treatment Apr. 6.	Treatment May 19.	Treatment May 27.	Relative amounts of curl June 15.
1		Check	Check	Check	200
2		Bordeaux 6–4–50	Bordeaux 6–4–50	Bordeaux 6–4–50	0
3		" "			10
4		" "	Potassium Sulfid	Potassium Sulfid	15
5		" "			12
6			Potassium Sulfid	Potassium Sulfid	127
			Ammoniacal Copper	Ammoniacal Copper	
7		Bordeaux 6–4–50	Carbonate	Carbonate	16
			Ammoniacal Copper	Ammoniacal Copper	
8	1–3	" "	Carbonate	Carbonate	12
			Ammoniacal Copper	Ammoniacal Copper	
8	4–7		Carbonate	Carbonate	44

Bordeaux 6-4-50 represents the normal mixture made with six pounds of copper sulfate, four pounds of good quick-lime, and fifty gallons of water.



EXPERIMENT II.

The orchard of Mr. H. S. Wright, upon which this experiment was made, is situated quite apart from other orchards of its kind, on the slope of West Hill, Ithaca, two or three hundred feet, perhaps, above the level of the principal portion of the city. It consists of young trees and suffered badly from curl in '98, but has not been sprayed until the season just passed. Elberta and Early Crawford varieties are about equally represented, the latter occupying mainly the southern portion of the block. The trees matured a good crop of fruit. Following the table of results by rows, is given one showing the comparative effectiveness of the solutions used.

EXPERIMENT II.—TABLE 1, SHOWING RESULTS BY ROWS.

Row.	Date of Treatment.	Treatment.	Relative amounts of curl June 16.
1		Check	12
2	April 5	Bordeaux 6–4–50	0
3	"	Bordeaux 3–2–50	2
4	"	Copper Sulfate 2–50	0
5	"	" " 2–500	4
6	"	Lime 2–5	6
7		Check	10
8	May 5	Bordeaux 6–4–50	0
9	"	" 3–2–50	0
10	"	Copper Sulfate 1–250	3
11	"	" " 1–500	3
12		Check	22
13	"	Copper Sulfate 1–500	2
14	"	" " 1–250	0
15	"	Bordeaux 3–2–50	0
16	"	" 6–4–50	0
17		Check	40
18	April 5	Lime 2–5	1
19	"	Copper sulfate 1–250	4
20	"	" " 1–25	0
21	"	Bordeaux 3–2–50	0
22	"	" 6–4–50	0
23		Check	30

EXPERIMENT II.—TABLE 2.

Treatments compared by averaging the amounts of curl on rows receiving the same treatment.

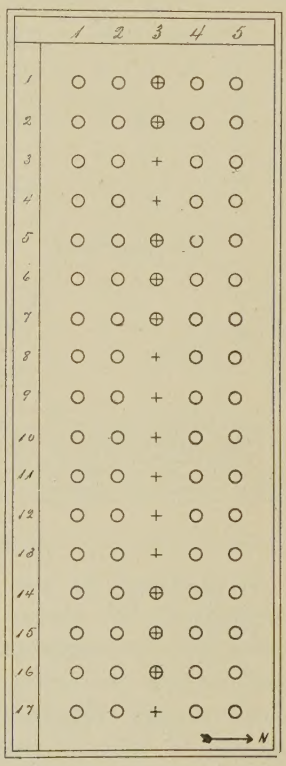
Date of Treatment.	Treatment.	Average amounts of curl.
	Check	23
April 5	Bordeaux 6–4–50	0
"	" 3–2–50	1
"	Copper Sulfate 1–25	0
"	" " 1–250	3.5
"	Lime 2–5	3.5
May 5	Bordeaux 6–4–50	0
"	" 3–2–50	0
"	Copper Sulfate 1–250	1.5
"	" " 1–500	2.5

In the Bordeaux mixtures used in the above tables, the first figure represents pounds of copper sulfate, the last gallons of water, and the middle one, separated from the others by dashes, represents pounds of unslacked lime. When copper sulfate or lime is used alone with water, the last number represents gallons of water and the first the copper sulfate or he lime in pounds.

EXPERIMENT III.

The trees used for this experiment were chosen from the orchard of Messrs. King and Robinson in Seneca Co., on the west shore of Cayuga lake two miles north of Trumansburg. When the curl first appeared in 1898, which was late in the season, the orchard was sprayed with Bordeaux, but without noticeable effect on the curl. The past year, it was again sprayed with Bordeaux, but early in April, and it was at that time that my experiments were made.

The varieties in this orchard most affected with curl in '98 were Elberta and Mountain Rose, Hill's Chili suffering very little; but, in '99, Hill's Chili seems to have been affected more than any other variety. The spraying was done April 8, the rows running across varieties as shown in the plan. Estimates were taken July 5. Table 1 gives results for different treatments; Table 2 for individual trees in a single row, enabling one to compare varieties. All of these trees are very large and were heavily loaded with fruit. There were no injuries to the foliage.



Checks are represented by +.

EXPERIMENT III.—TABLE 1.—A COMPARISON OF TREATMENTS.

Row.	Treatment.	Amount of curl.
1	Bordeaux, 6–6–50	One leaf to the tree
2	" 3–3–50	Seven leaves to the tree
3	Lime, 2–5	Fifteen leaves to the tree
3	Check	Three per cent
4	Copper sulfate, 4–50	Twelve leaves to the tree
5	" " 1–100	Forty leaves to the tree

EXPERIMENT III.—TABLE 2.—A COMPARISON OF VARIETIES.

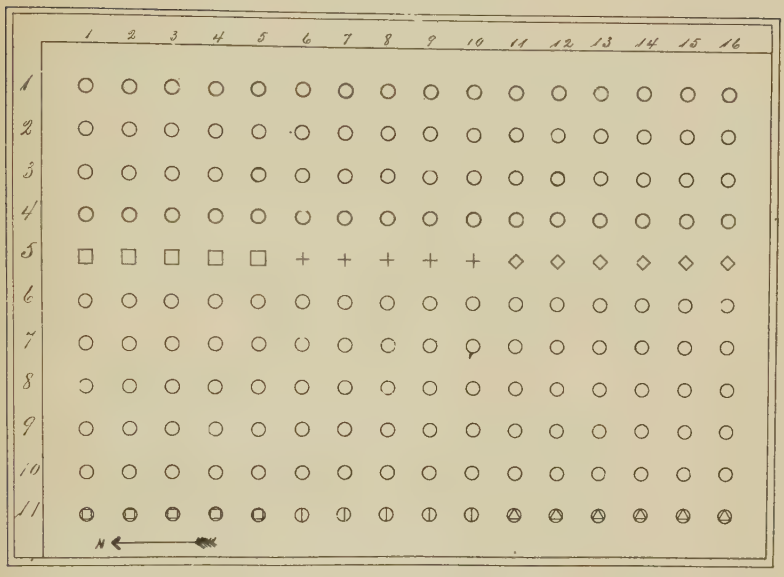
Tree.	Variety.	Treatment.	Amount of curl.
1	Hill's Chili	Lime	None
2	"	"	Less than 1 per cent
3	"	Check	7 per cent
4	"	"	None (set later)
5	Brigdon	Lime	¼ per cent
6	"	"	¼ per cent
7	"	"	¼ per cent
8	"	Check	Less than 1 per cent
9	"	"	" " "
10	"	"	" " "
11	Mountain Rose	"	5 per cent
12	"	"	5 per cent
13	"	"	5 per cent
14	"	Lime	Five leaves to the tree
15	"	"	" " "
16	Globe	"	" " "
17	"	Check	5 per cent.

In the Bordeaux mixtures used in the above tables, the first figure represents pounds of copper sulfate, the last gallons of water, and the middle one, separated from the others by dashes, represents pounds of unslacked lime. When copper sulfate or lime is used alone with water, the last number represents gallons of water and the first the copper sulfate or the lime in pounds.

EXPERIMENT IV.

Experiment IV was made upon a young Elberta orchard belonging to Mr. Henry Lutts situated two miles east of Youngstown in the northwestern corner of Niagara county. The orchard had received no treatment before '99. The trees have been set five years and were badly attacked with curl in '98. There was no crop of fruit the past season. The estimates have all been made by actual counting and the results are given in a table following the plan of this experiment. As may be seen from the plan, there are eleven rows of trees with sixteen trees to the row. Checks are indicated by the plus sign, those treated with Bordeaux 6-8-50 by a square, and those with Bordeaux 3-3-50 by a tilted square. Lime 1-5 is represented by an inscribed line, lime 1-3 by an inscribed triangle, and lime 1-2 by an inscribed square.

PLAN OF EXPERIMENT IV.



EXPERIMENT IV.—TABLE OF RESULTS WITH ELBERTA TREES OBTAINED BY ACTUAL COUNT.

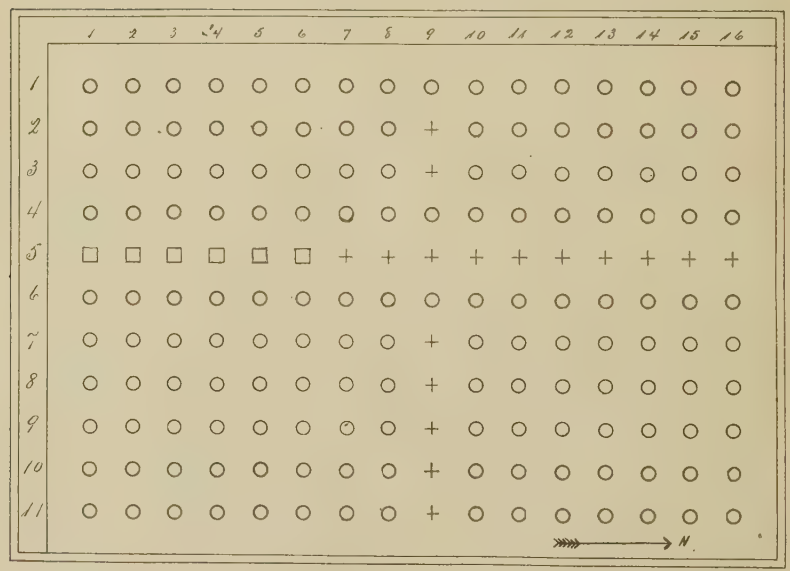
Row.	Tree.	Treatment Apr. 11–13.	Treatment May 11–13.	Relative amounts of curl June 13.
1		Bordeaux 6–4–50	Bordeaux 4–4–50	8
2		" 6–6–50	" 6–6–50	0
3		" 6–6–50	" 3–3–50	23
4		" 3–3–50	" 3–3–50	25
5	1– 5		" 6–8–50	247
5	6–10	Check	Check	3520
5	11–16		Bordeaux 3–3–50	608
6		Bordeaux 6–4–50		209
7		Copper sulfate 4–50		854
8		" " 4–50	Copper sulfate 1–250	450
9		" " 4–50	" " 1–500	512
10		" " 4–50	Bordeaux 4–4–50	70
11	1– 5	Lime 1–2		640
11	6–10	" 1–5		1552
11	11–16	" 1–3		1376

In the Bordeaux mixtures used in the above table, the first figure represents pounds of copper sulfate, the last gallons of water, and the middle one, separated from the others by dashes, represents pounds of unslacked lime. When copper sulfate or lime is used alone with water, the last number represents gallons of water and the first the copper sulfate or the lime in pounds.

EXPERIMENT V.

The trees included in this plot were also selected from one of the orchards belonging to Mr. Lutts. They were all of the Beer's Late variety and were enclosed on three sides by unsprayed trees. They curled badly in '98, though not so much as the Elbertas, and have not been sprayed until the past year. The trees are six years old and have about twenty thousand leaves to the tree. There was no crop in '99. A plan and table of results follow, as in the preceding experiments.

PLAN OF EXPERIMENT V.



From Mr. Lutts' block of the Beer's Late variety. The number and arrangement of of the trees is the same as in experiment IV and the signs used have the same significance as in that experiment.

EXPERIMENT V.—TABLE OF RESULTS WITH BEER'S LATE.

Row.	Trees.	Treatment Apr. 11–13.	Treatment Apr. 11–13.	Amounts of curl June 13.
1		Bordeaux 6–4–50	Bordeaux 4–4–50	None
2		" 6–6–50	" 6–6–50	"
3		" 6–6–50	" 3–3–50	"
4		" 3–3–50	" 3–3–50	"
5	1–6	.....	" 6–8–50	Two leaves to the tree
5	7–16	Check	Check	4 per cent on all checks
6		Bordeaux 6–4–50	.....	Ten leaves to the tree
7		Copper sulfate 4–50...	.....	1 per cent
8		" " 4–50...	Copper sulfate 1–250..	½ per cent
9		" " 4–50...	" " 1–500..	½ per cent
10		" " 4–50...	Bordeaux 4–4–50	None
11		Lime 2–5	.....	2 per cent

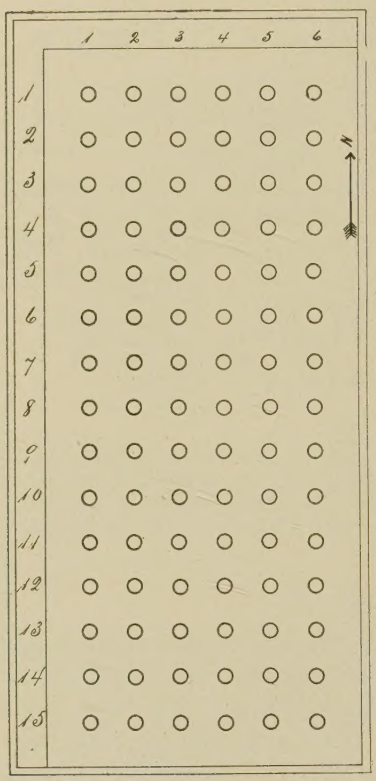
In the Bordeaux mixtures used in the above table, the first figure represents pounds of copper sulfate, the last gallons of water, and the middle one, separated from the others by dashes, represents pounds of unslacked lime. When copper sulfate or lime is used alone with water, the last number represents gallons of water and the first the copper sulfate or the lime in pounds.

EXPERIMENT VI.

This experiment was made upon a block of Elberta trees chosen from the orchard of Mr. W. T. Mann, one mile west of Somerset, in the northeastern corner of Niagara county. The trees were set in '94 and suffered from the curl in '97 and '98, but were not sprayed before '99. They are very thrifty and bore a large crop of fruit the past season. The orchard from which these trees were selected was sprayed early in the spring with Bordeaux.

Injuries to foliage were observed with some care in this block. The lime used was of the best quality and both it and the copper sulfate were carefully weighed, as was done in the other experiments; but it soon became evident that the normal Bordeaux mixture contained too much copper sulfate for the foliage of the peach. Injuries began to appear two weeks after the second spraying. The foliage took on an unhealthy look; shot-holes and yellow tips were abundant and many leaves fell from the trees. By June 14, the injuries to rows 3, 4, 5, 7, 8 and 12 were equally apparent, and doubtless greater than those

sustained by the check rows from the attacks of the curl. Row 2, treated with comparatively weak Bordeaux, did not at that time show much injury. All of the rows which received only the first spraying remained in fine condition.



By July 8, on all trees sprayed late with Bordeaux the foliage was thin and the ground beneath the trees was thickly covered with yellow leaves. On August 8, the rows all appeared about alike, since the injured leaves had mostly fallen or become concealed by the new growth. Very few curled leaves had fallen from the checks. The loss of foliage on rows receiving the second spraying with Bordeaux affected to some extent the quality of the fruit on these rows.

Injuries to foliage in experiments IV and V were practically the same as those recorded above.

EXPERIMENT VI. —TABLE OF RESULTS.

Row.	Treatment April 14.	Treatment May 15.	Relative amounts of curl June 14.
1	Bordeaux 6–4–50		18
2	" 6–4–50	Bordeaux 3–3–50	2
3	" 6–4–50	" 4–4–50	0
4	" 6–6–50	" 6–6–50	0.50
5	" 3–3–50	" 3–3–50	2
6	Check	Check	1500
7		Bordeaux 6–6–50	31
8	Copper sulfate 4–50	" 4–4–50	0.33
9	" 4–50	Copper sulfate 1–250	0.50
10	" 4–50		19
11	" 2–50		34
12	Lime 1–2½	Bordeaux 4–4–50	0.66
13	" 1–2½		375
14	" 1–5		750
15	Check	Check	1500

CONCLUSIONS.

There is no good reason for giving up the Elberta or any other variety of peach sensitive to leaf-curl, as this disease can be controlled by spraying at trifling expense.

Of the three substances employed as fungicides in these experiments, the Bordeaux mixture is the most useful; and, though several different strengths of this mixture have been found nearly equal in efficiency the past season, for the early spraying a strong solution is recommended. When Bordeaux of good strength is used early and a season of warm, dry weather follows, continuing as late as the middle of May, a second spraying is not profitable. But if the weather is cold and wet, it is well to spray again with Bordeaux after the petals fall, using only two pounds of copper sulfate (with excess of lime) to fifty gallons of water, for, notwithstanding some statements to the contrary, the foliage of the peach seems sensitive to stronger solutions.

The treatment, then, for the prevention of peach leaf-curl based upon my own and other experiments is briefly as follows:

1. Spray with Bordeaux consisting of 6 lbs. of copper sulfate, 4 lbs. of good quick-lime, and 50 gals. of water about the first of April when the buds are beginning to swell.

2. Spray again when the petals have fallen with Bordeaux consisting of 2 lbs. of copper sulfate, 2 lbs. of good quick-lime, and 50 gals. of water. If the weather of April and early May is warm and dry, this second spraying may be omitted.

Lime or copper sulfate alone with water have been almost as effective as Bordeaux the past season when used for the first spraying and followed later by Bordeaux, but their effects are not so lasting, particularly in rainy weather, and, whether the season is favorable or unfavorable, the second spraying with Bordeaux should not be omitted when lime or copper sulfate are used alone for the first.

HOW TO MAKE THE BORDEAUX.

Prepare a stock solution by suspending 25 lbs. of copper sulfate in a coarse sack in 25 gals. of water for a day or more until completely dissolved. To make 50 gals. of strong Bordeaux for the early spraying, take 6 gals. of the stock solution and dilute

it with 19 gals. of water. Weigh out 4 lbs. of the best quick-lime, slack it slowly, dilute to 25 gals., and strain through a metallic sieve into the copper sulfate solution while the latter is being stirred.

To prepare 50 gals. of the weak Bordeaux for the late spraying, proceed in the same manner, using 2 gals. of the stock solution of copper sulfate, 2 lbs. of quick-lime, and 48 gals. of water.

Those conducting spraying operations on a larger scale will find it convenient to prepare fifty gallons or more of the stock solution of copper sulfate, keeping it covered to prevent evaporation, and to slack a considerable quantity of lime at once and keep it in the form of a paste in a barrel partially sunk in the ground or in a trough made specially for the purpose. If the surface of the paste is kept covered with a little water, the lime may be preserved for an indefinite length of time in this form and the amount required for a given quantity of Bordeaux determined by testing the mixture with a solution of potassium ferrocyanid in about ten parts of water. A drop of this solution on being added to a solution of copper sulfate produces immediately a dark reddish brown color. When sufficient lime has been added in the preparation of the Bordeaux mixture, this change in color does not occur on the addition of potassium ferrocyanid. It is well to add a little more lime, even after the test indicates a sufficient quantity, since a large excess of lime is rather a benefit than otherwise, while a slight excess of copper sulfate may prove injurious to the foliage. A first-class spraying outfit and a convenient water supply are very important where much spraying is attempted. W. A. MURRILL.

The writer's thanks are due Messrs. King and Robinson, of Trumansburg, Mr. H. S. Wright, of Ithaca, Mr. Henry Lutts, of Youngstown, and Mr. W. T. Mann, of Barker, who have offered their orchards for the above experiments and most heartily coöperated with him to make them successful.